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Communication Framework for Jointly Addressing Issues of Routing Overhead and Energy Drainage in MANET

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Abstract

The advancement into smart mobile devices has accelerated the adoption of various pervasive computing based ubiquitous applications, where Mobile Adhoc Network (MANET) has extended its usability from hard core military applications to civil society applications. The success for routing requires a robust computational mechanism of routing based on the collaborative framework of energy (i.e. battery power), signal strength and zonal routings. The paper presents a framework of novel routing technique in order to jointly address the problem pertaining to routing overhead and energy drainage among the mobile nodes. Different from conventional simulation mechanism, the paper presents a communication district with inclusion of auxiliary nodes for minimizing the overhead during the routing process. The outcome of the proposed study shows significant reduction in routing overhead along with energy efficiency as compared to existing AODV and DSDV protocols.

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Keywords: Mobile Adhoc Networks; Signal Strength; Routing Protocol; Routing Overhead.

1. Introduction

Mobile adhoc network is generated from the self-configuring mobile nodes. It is characterized by mobile nodes with zero infrastructures and decentralized (Fig.1). Usually the mobile nodes could be any form of communication devices e.g. smart phone, personal desktop assistance, tablet PC, etc. The physical location of a mobile node in adhoc network is constantly changing that also affects the network topology with higher degree of uncertainty. Owing to such formation of dynamic topology, the status of the link changes and so is its connectivity with the adjacent mobile nodes[1]. With a new link added or old link broken, the mobile node takes up a decision of performing routing in order to be in the network or get disassociate with the network. Therefore, in order to normalize the traffic system in mobile adhoc network, numerous researchers have put forward various routing protocols to handle such issues. There are basically three types of routing technique in mobile adhoc network i.e. i) Reactive or on-demand routing protocol, ii) Proactive or table-driven protocols, and iii) Hybrid routing protocol[2]. The reactive routing protocol constructs a routing table which is completely on-demand and without any dependency of prior information about the nodes. Some examples of reactive routing protocols are AODV[3], DSR[4]. The proactive routing protocol will need to share the addresses of mobile nodes to be entered in a routing table before constructing routes. Some examples of reactive routing protocols

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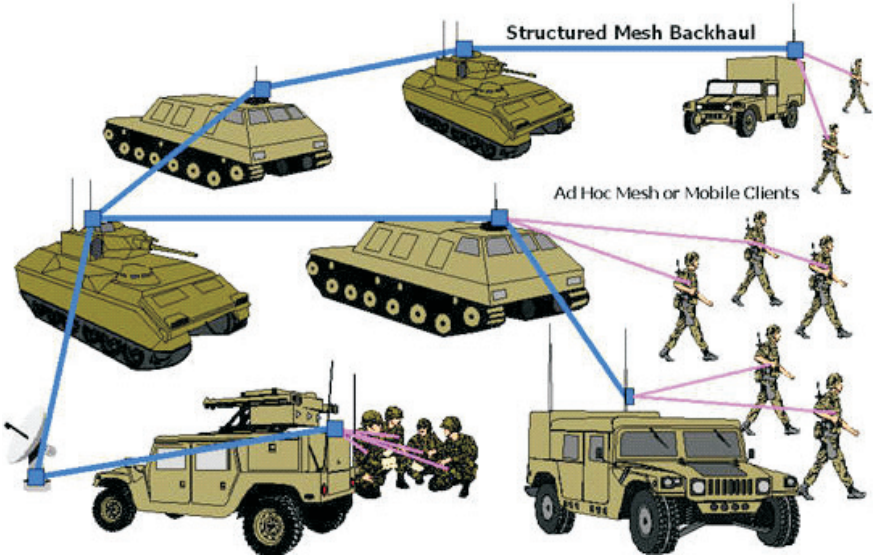


Fig. 1. A typical scenario of Communication in Mobile Adhoc Network.

are DSDV[5], OLSR[6], FSR[7] etc. Hybrid routing protocols just make use of advantageous features of both proactive and reactive routing protocols e.g. ZRP. The applications of mobile adhoc network are crisis management, combat operation, defence and military applications etc.

There are various literatures to show that enough studies towards mobile adhoc network have been focussed towards routing problems[8], energy problems[9], security problems[10] etc. But, maximum number of problems is related to routing factor in mobile adhoc network. Hence, it is quite understood that there has been enough studies that have focussed on routing problem since more than last decade. However, the problem of routing is still unsolved.

This paper presents a novel routing technique that emphasize on establishing a better balance between overhead minimization and energy efficiency on the basis of signal strength. Section 2 discusses about the prior work carried out pertaining to signal strength in mobile adhoc network followed by problem identification in Section 3. Section 4 highlights the contribution of proposed study followed by Section 5 that discusses about research methodology. Section 6 discusses about result discussion followed by summary of the paper in Section 7.

2. Review of Literature

This section discusses about the existing routing techniques using signal strength as a parameter in mobile adhoc networks. Our prior study[11] has already discussed about the work being carried out using signal strength in mobile adhoc network along with discussion of the research gap. We have also presented a simple routing protocol considering Received Signal Strength (RSSI) for ensuring the routing quality of the mobile adhoc network[12]. The study outcome show efficient outcome with respect to existing DSR protocol in perspective to delay, energy, delivery ratio, and overhead. The recent work carried out by Halder *et al.*[13] has used RSSI for addressing the problem of localization issues. The study also enhances the link quality indicator. However, the usage of RSSI was not carried out to normalize the flow of the traffic but was more concern with unit route quality. Similar category of the work is also carried out Zhu and Alsharari[14] who have focussed on developing a novel optimization technique. The authors have developed a unique transmission model considering the shadowing effect. Reduction of shadowing effect in mobile adhoc network was also addressed by Debnath *et al.*[15]. The recent work carried out by Gaur and Pant[16] has used signal strength for the purpose of providing security. Peng *et al.*[17] have also carried out a study using RSSI in order to evaluate the network lifetime of mobile adhoc network. The authors have used a unique interpolation technique for evaluating more information from the signal strength. The outcome of the study was evaluated using errors in energy estimation.

Usage of RSSI was also seen in the study of Vinothkumar and Asokan[18] using a threshold based scheme. The authors used signal strength for confirms the quality of the link in mobile adhoc network. Hence, it can be seen that there are various studies being conducted in order to use RSSI in mobile adhoc network. However, 85% of the research-based manuscript was found to use RSSI concept more on wireless sensor network and very less on mobile adhoc network. The next section discusses about the problem identification of the existing study.

3. Problem Identification

The prior section has discussed about some of the relevant research techniques that have used RSSI as the prime source of enhancement in communication of mobile adhoc network. All the studies have acted as a good guideline to carry out future research work towards further enhancement in communication performance, but still, there are few facts which are found to be unaddressed in the prior literatures. Therefore, the problems that are identified from the existing literatures are as follows:

- The existing study using RSSI consider the problems of localization and very less on the routing process. There are extremely less research work being carried out for using localization towards efficient routing process in mobile adhoc network.
- Till date there are various routing protocols that focus on various problems including energy minimization and routing overhead. But none of such work has used RSSI as the leveraging parameter for enhancing the routing behaviour.
- Although, there are various energy-efficient routing techniques in mobile adhoc network, but it is yet to explore if the energy efficient routing is also capable of minimizing the routing overhead in mobile adhoc network and thereby enhance the network lifetime.
- Formulation of the routing is carried out in the form of clustering and group in large scale mobile adhoc network. Unfortunately, there was no exploration for the fact if there is an existing multiple groups/clusters overlapping. In such case, all the geometric-based approach fails to sustain in dynamic topology.
- The formations of the routes are basically of two types: i) stabilized routes and ii) unstabilized routes. Stabilized routes are termed as those routes established between nodes with higher signal strength and unstabilized routes are established between the nodes with weaker signal strength. Till date, there is no such study to define such parameters and associate with the energy to combinely solve energy and routing overhead issues in mobile adhoc network.

Developing a routing technique to confirm sustaining massive uncertainties are quite challenging. Although, prior researchers have deliberately attempted to come out with solution to reduce routing overhead, but there was only few studies to explore in this regards. In fact, this area of jointly addressing the problem of routing overhead minimization along with an effective retention of energy efficiency for enhanced network lifetime is one of the most challenging and novel research direction till date.

The problem statement of the proposed study can be stated as "*It is a computationally challenging task to develop a simple routing technique that uses improved concept of signal strength for the purpose of reducing the routing overhead and energy drainage together in mobile adhoc network.*" The next section highlights the contribution of the proposed system followed by further discussion of research methodology.

4. Proposed System

The prime purpose of the proposed study is to present a framework of novel routing technique that has the capability of minimizing routing overhead with an aid of improved signal strength considering the case study of mobile adhoc network. In order to mitigate the challenges of dynamic topology of mobile adhoc network, we present a completely new scenario of routing, where the conventional mechanisms of routing are completely discarded. The prime features as well as novelty in this proposed study are as follows:

- To develop an entirely novel routing protocol in mobile adhoc network for resisting routing overhead.
- To incorporate a feature that can ensure maximum data delivery and reduce energy consumption.

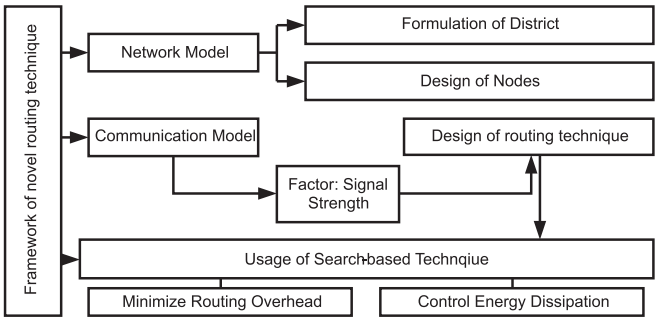


Fig. 2. Schema Adopted in Research.

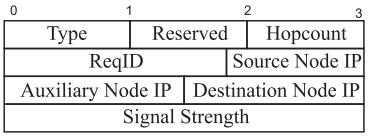


Fig. 3. Beacon Format used in Routing.

- To design a feature that can maintain a better balance between the data delivery performance and energy efficiency at same time.

The next section discusses about the research methodology that will further elaborate the design techniques adopted to develop the proposed system.

5. Research Methodology

The development of the proposed study is carried out using analytical research methodology. The adopted schema of the proposed novel idea is shown in Fig. 2. Usually, the mobile nodes are infrastructure free in mobile adhoc network but we consider presence of another types of nodes called as Auxiliary Node (AN). Interestingly, AN doesn't take part in data dissemination process but they are helpful in sharing the signal strength information to the requesting mobile node in order to assist in decision making for routing. Unlike conventional scheme, the proposed system doesn't consider a typical cluster-based or group communication system, but it considers that all the mobile nodes resides in a simulation area which is restricted by particular radius called as Communication District (CD). We divide each communication district into further smaller regions called as Sub-Districts (SD) that is formed by interception of particular number of chord in CD.

The proposed system uses a specific format of routing beacon as shown in Fig. 3. The overall size of the beacon is 30 bits which carries information e.g. request ID, auxiliary node IP, Source and destination node IP, and signal strength of originator node.

The design mechanisms of the modules along with their operations are discussed here:

- **Formulation of District**: The proposed technique doesn't consider a rectangular or squared-based simulation area, but it considers multiple overlapping communication zone of any shape called as district. Figure 4 shows the flow of the district formation which is done by intercepting various chords with respect to intercepting angle on considered simulation area (which is elliptical or circular different from conventional rectangular shape).
- **Design of Nodes**: The proposed study considers designing two different types of nodes in mobile adhoc network viz. mobile nodes and auxiliary nodes (Fig. 5). The mobile nodes are just like normal nodes that perform conventional task of data dissemination and routing operation. The mobile nodes are allowed mobility restricted to the elliptical simulation area only. Hence, the system considers the presence and mobility within a defined map i.e. districts and sub-districts.

  The proposed system also introduces another type of node called as auxiliary node, which performs task almost like a relay node. However, we enhance the concept by incorporating new functionalities for Auxiliary Node (AN). The design principle considers presence of at least one AN in one SD, which will mean that number of AN depends on number of SDs. The sole responsibility of AN will be to collect and disseminate signal strength information about any mobile nodes that passes via them. As AN is a static node, hence, we consider that AN doesn't have any constraint of resources (energy and memory).

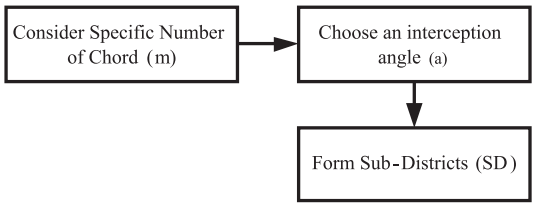


Fig. 4. Formulation of Communication District.

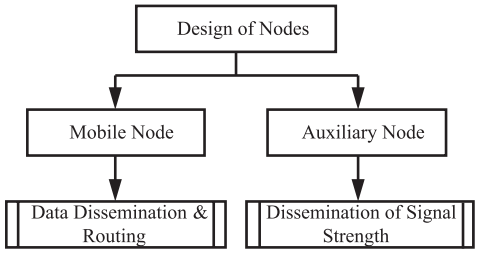


Fig. 5. Design of Nodes in Proposed System.

- **Design of Routing Technique**: The design of the proposed routing technique is highlighted in Fig. 6. The routing operation initiates with a query generation of any mobile node residing at any point of sub-district SD. A primary search is initiated when the query of mobile node is transmitted to auxiliary node which forwards a bidirectional message requesting for the information of the signal strength using RSSI. Bi-directional messaging is a technique when a single search beacon is broadcasted by one auxiliary node in one SD to other auxiliary node in another SD. The search continues when the best signal strength is identified. The termination of search results in two consequences i.e. in case of close-end search the AN with specific signal strength for probable destination node is received. Based on the response, the requesting node develops route with the newly searched mobile node of matched signal strength, where the link stability is quite high. However, for open-end search (means the last AN didn't find the matched signal strength owing to dynamic topology), the routing technique performs perimetric search. Such search are formulated by the source AN to another auxiliary node directing to the perimeter of the simulation area. Although, it is expected that 90% of the search will be terminated in the primary search, but due to presence of random mobility there is a possibility that destination node may move out during the process of search. Hence, secondary search assists in capturing the mobile node with specific signal strength. Hence, secondary search will perform 100% termination resulting in extremely less overhead.

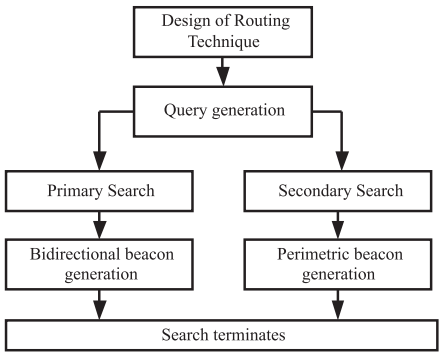
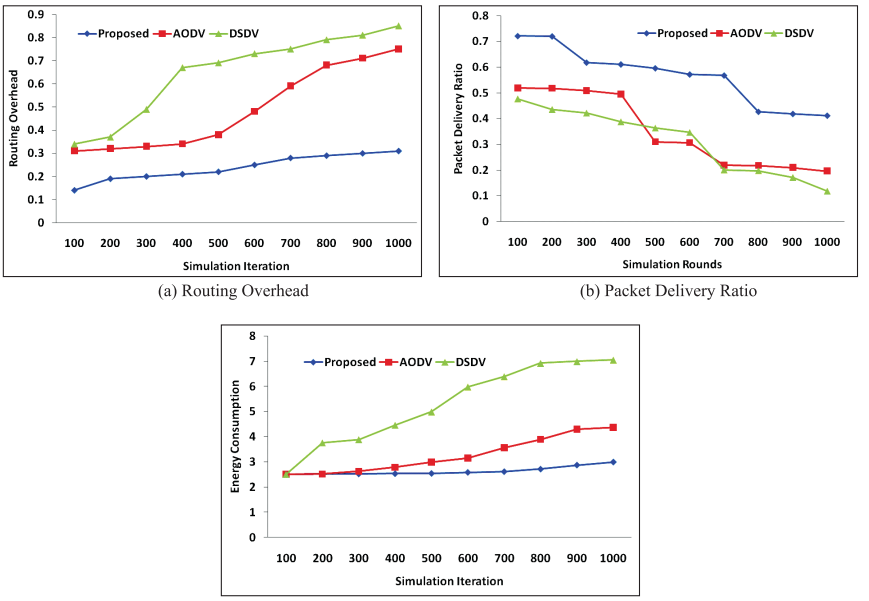


Fig. 6 Design of Proposed Routing Technique.

- **Mitigating Overhead and Energy Consumption**: Normally, a mobile node have various energy-related issues those surfaces owing to the dynamic topology in mobile adhoc network. Another interesting part of the study is that although there are usages of bidirectional messages used by the auxiliary nodes. But after the termination of search, the system either finds the node that matches with query or else it continue in its secondary search. In both the cases, the routing information is updated after it passes from one to another auxiliary node that results in fresh routing message circulation and also avoids in collision. As the entire operation of routing takes place in run time; therefore, there is no way that unnecessary memory is accumulated, which retains the optimum performance of a mobile node in terms of energy and communication. The proposed system always ensure that ay any position of the destination node within a communication district, the probability of data to reach the destination is exponentially high although it may consume some processing time in the preliminary search rounds. But however, with more routing operation, the system gathers more update information about the node's resource and signal strength status that also increasing higher probability of stabilized links even in presence of dynamic topology in mobile adhoc network. Another important fact is messages for two different types of search carry different flag but with same fields and bits allocation. Hence, without any memory consumption, the updating of the routing message can be done and this operation immensely assists in avoiding any forms of routing overhead from one sub-district to another.



(a) Routing Overhead

(b) Packet Delivery Ratio

(c) Energy Consumption

Fig. 7. Comparative Analysis Outcome.

6. Result Discussion

The design and development of the proposed system is carried out in Matlab considering simulation area of $1200 \times 1500\ m^2$. The simulation study is carried out over 500–1000 nodes with initialized energy of 0.5 J and the observations are made for 1000 simulation iterations. A mobile node is also initialized with variable transmission ranges along with usage of random mobility model. The outcome of the routing technique discussed in proposed study was compared with that of conventional routing technique of AODV and DSDV with respect to the performance parameters of routing overhead (Fig. 7(a)), packet delivery ratio (Fig. 7(b)), and energy consumption (Fig. 7(c)) with increasing simulation rounds. The outcome in Fig. 7(a) clearly shows that proposed system has approximately 40% improvement in routing overhead as compared to AODV and DSDV. The outcome in Fig. 7(b) exhibits that there is a significant improvement of data transmission i.e. packet delivery ratio. The trend of gradient descent for packet delivery is due to declining energy with the increasing simulation rounds. The outcome of Fig. 7(c) highlights the performance of the energy factor among the systems.

The root cause of this outcome is that existing routing techniques entire starts with conventional route discovery process, where the study considers constructing a route to be maintained by node-to-node. For larger area, the existing system applies group or cluster based concept where the routing is performed and assisted with cluster leader. However, our proposed system is completely free from any defined group, which is redefined using the novel concept of communication district. Moreover, the system doesn't hold up any state routing information that happens in AODV. The system also doesn't have any requirement to extract any identity-based information that happens in DSDV resulting in faster generation of route even in presence of dynamic topology.

The complete load of route construction and maintenance is carried out by AN that results in significant retention of energy of the mobile nodes. The complete assistance of routing is carried out only using signal strength information which results in selection of routes. Depending on the type of the query message, the auxiliary node decides the appropriate intermediate node just on the basis on signal strength at that instant of time. A simple search-based technique is used that gives an assurity of data delivery to the destination node provided no new nodes join the network during the simulation in progress. The selection and constructions of routes on the basis of signal strength is quite a novel idea and is highly cost effective in nature.

7. Conclusions

Routing has always been the most challenging problem in mobile adhoc network. Although there are massive archives and volumes of research manuscript found to solve the problem of energy, routing, security, etc, but in really, none of these stated problems have been completely met its best solution till date. This paper highlight of such problem which is found quite ignored in the existing study i.e. jointly addressing routing overhead issues along with enhancing the network lifetime using improved signal strength in presence of dynamic topology of mobile adhoc network. This paper introduced some of the new concept e.g. i) a new topology constructed from communication district inspite of using conventional rectangular-based simulation approach, ii) the new topology has a unique style of sourcing the query that is passed on to auxiliary node, which is newly introduced in the proposed system. The entire mechanism of interaction between the mobile nodes and auxiliary nodes ensures lowest routing overhead that indirectly controls the energy dissipation in mobile adhoc network. Therefore the proposed system can successfully minimize the routing overhead as a bidirectional and perimetric beacon generation ensures reaching the destination node irrespective of the mobility involved in it. In this mechanism, there is a less need to perform re-transmission as query once initiated will be served by the auxiliary node in the transmission area. These phenomenons significant reduce the re-transmittance energy in MANET. The outcome of the study was evaluated using performance parameters of routing overhead, packet delivery ration, and energy consumption to find it excels better than most frequently used reactive and proactive routing technique. Our future work will be in the direction of the further optimizing the technique to ensure more retention of network lifetime.

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